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SURVEYOR SPACECRAFT

DEVELOPMENT PLAN

~~GROUP 4~~
~~Downgraded at 3 year intervals; declassified after 12 years~~

HUGHES

SPACE SYSTEMS DIVISION
AEROSPACE GROUP
HUGHES AIRCRAFT COMPANY

GPM

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SURVEYOR SPACECRAFT

DEVELOPMENT PLAN

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No. 2251/25

7 AUGUST 1961

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SURVEYOR SPACECRAFT LABORATORY
SPACE SYSTEMS DIVISION • AEROSPACE GROUP
HUGHES AIRCRAFT COMPANY • CULVER CITY, CALIFORNIA

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SURVEYOR SPACECRAFT DEVELOPMENT PLAN

This volume presents the Surveyor Spacecraft Development Plan agreed upon during negotiations on the definitive contract and supersedes Development Plan No. 2250/17, dated 9 June 1961. It consists of two essential parts:

- Master Summary Spacecraft Development Plan
  - * Spacecraft Engineering and Fabrication Plan
  - * Master Test Plan
  - * Master Mission Operations Plan
- Master Phasing Plan

The Summary Spacecraft Development Plan presents the major system milestones. These milestones are described in greater detail in the three supplementary plans which highlight accomplishments in the engineering and fabrication, test, and mission operations areas, respectively. The Master Phasing Plan has been included to show the time sequencing of the major tasks as related to system accomplishments and also to indicate key decision dates and significant interfaces with the other participants on the Surveyor program. Included with the Master Phasing Plan are the task descriptions of each of the elements of the Surveyor Spacecraft Project. There are 14 such tasks and the cost for completing each task can be identified in a corresponding cost estimate sheet supplied under separate cover. These Master Development and Phasing Plans form the basis for the Hughes Aircraft Company cost estimate for its definitive contract on the Surveyor Spacecraft System.

MASTER SUMMARY SPACECRAFT DEVELOPMENT PLAN

The Master Program Plan for the Surveyor Spacecraft System is presented in the accompanying charts and is divided into four basic categories:

Surveyor Spacecraft Summary Program Plan

Surveyor Spacecraft Engineering and Fabrication Plan

Surveyor Spacecraft Master Test Plan

Surveyor Spacecraft Mission Operations Plan

The salient features of each of these categories are described below.

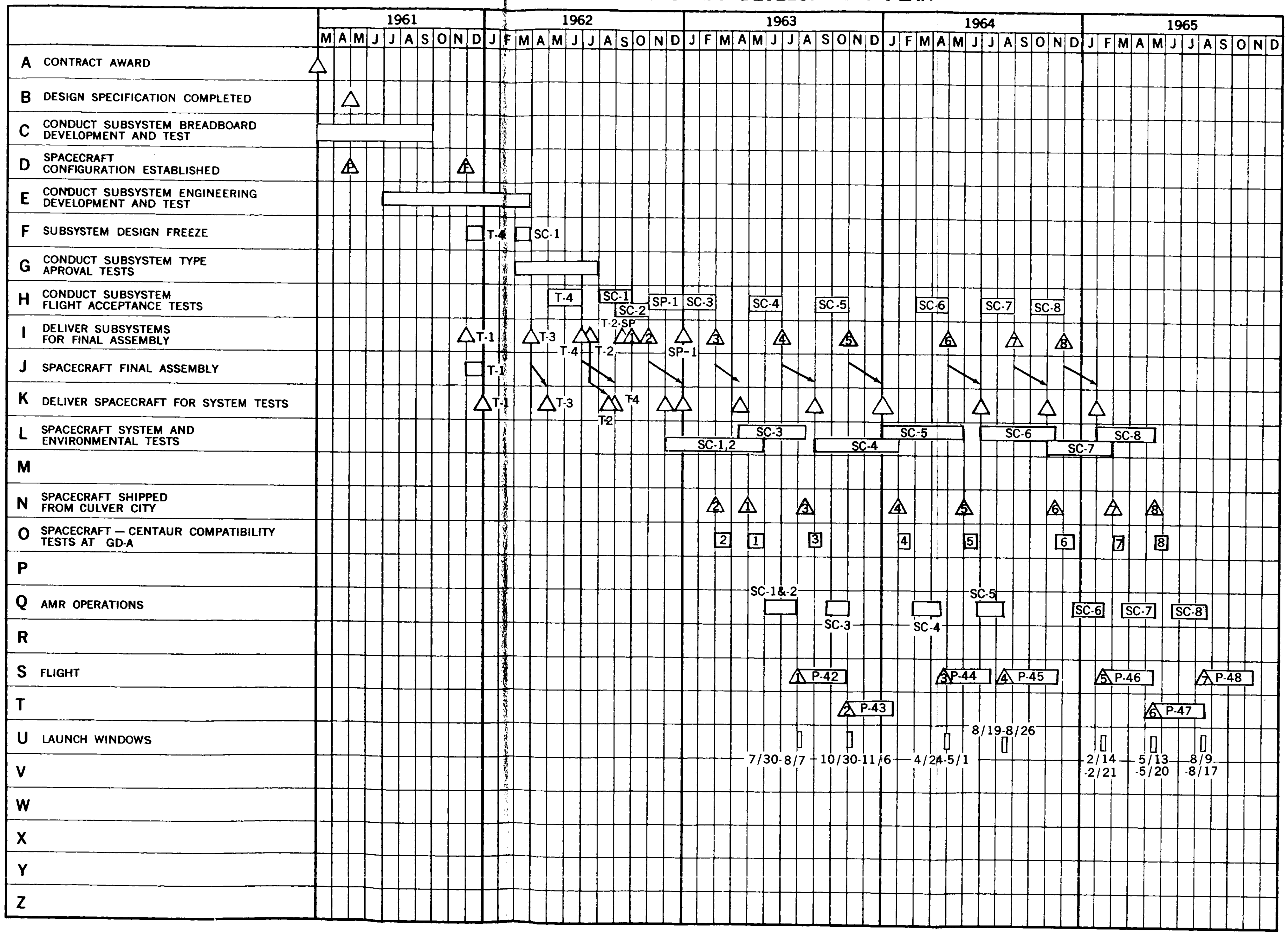
1. Summary Program Plan

This chart presents key development items involved in Spacecraft Engineering and Fabrication, Test, and Mission Operations. While this Summary Plan defines major hardware delivery throughout the development cycle, detailed milestones are described in the Engineering and Fabrication, Test, and Operations Plans. The progress of individual spacecraft is traced through various development activities at Hughes, General Dynamics Astronautics, and AMR and involves the following steps.

The final assembly activity accepts qualified subsystems, installs these units on the spaceframe, checks electrical interconnections throughout the harness, and provides final assembly and checkout of all units. Necessary optical and mass alignment is performed at this time. At the completion of this 2-month activity, the spacecraft is delivered to systems test where it undergoes checkout tests which confirm the operation of each subsystem plus physical compatibility and interaction of all units. Environmental tests subject the spacecraft to the rigors of high and low temperature, vacuum, vibration, and other environmental requirements. The dummy run test which simulates an entire launch, transit, and lunar operations cycle is the last test performed at the Culver City laboratories. Each spacecraft is then shipped to General Dynamics, Astronautics, San Diego, for a complete Surveyor/Centaur compatibility test, which includes physical, electrical, and RF compatibility. Necessary ground support equipment is provided by Hughes to assist in these compatibility tests. The spacecraft is then shipped to Cape Canaveral (AMR) where checkout and functional tests are performed, and the spacecraft is integrated with the Centaur boost vehicle. Necessary prelaunch assembly of hazardous ordnance such as rocket motors, squibs, and explosive items is accomplished; and the sterilization cycle is completed. Final integration and performance tests are made on the launch pad in conjunction with the Deep Space Instrument Facility (DSIF) and boost vehicle requirements and culminate in the final countdown and launch.

The preparatory operations at AMR are arranged to ensure that two spacecraft are always in equal states of readiness so that in the event of a

MASTER SUMMARY SPACECRAFT DEVELOPMENT PLAN



malfunction or accident occurring to one spacecraft, the launch can be accomplished with the stand-by unit. After the Centaur has injected the Surveyor into the lunar transit trajectory, it is a Hughes responsibility to perform the necessary midcourse trajectory corrections, achieve a lunar orbit, descent, landing, and perform the scientific experiments specified by JPL. The CDC/DSIF will originate experiment commands and sequencing, and receive scientific data resulting from these experiments.

2. <u>Spacecraft Engineering and Fabrication Plan</u>

The spacecraft development effort is essentially divided into the following phases:

- Subsystem breadboard development, which occurs during the first 8 months of the program.
- Subsystem engineering development, which overlaps breadboard development by 4 months and encompasses a total of 9 months.
- Subsystem prototype development and type approval testing, which continues over a 5-month period.

The culmination of this development effort is the fabrication and acceptance testing of qualified subsystems to be integrated into prototype and flight spacecraft. At the completion of the spacecraft development effort, the first prototype spacecraft (T4) will go into final assembly in July 1962 and will be available for systems tests on 1 September 1962. The first flight unit, SC-1, enters final assembly in October 1962 and is delivered to test on 1 December 1962.

For the seven scheduled launches, eight spacecraft will be provided so that a complete spare will always be available throughout the program. Additionally, there will be one set of flight-approved spare subsystems which will be available to back up systems test activity at all times. Both the spare spacecraft and subsystems spares will be appropriately updated in order to provide fully representative spares capability for each spacecraft launch configuration. Consequently, in the event of a malfunction it is possible to replace either an entire spacecraft or major subsystem, depending upon the nature of the problem.

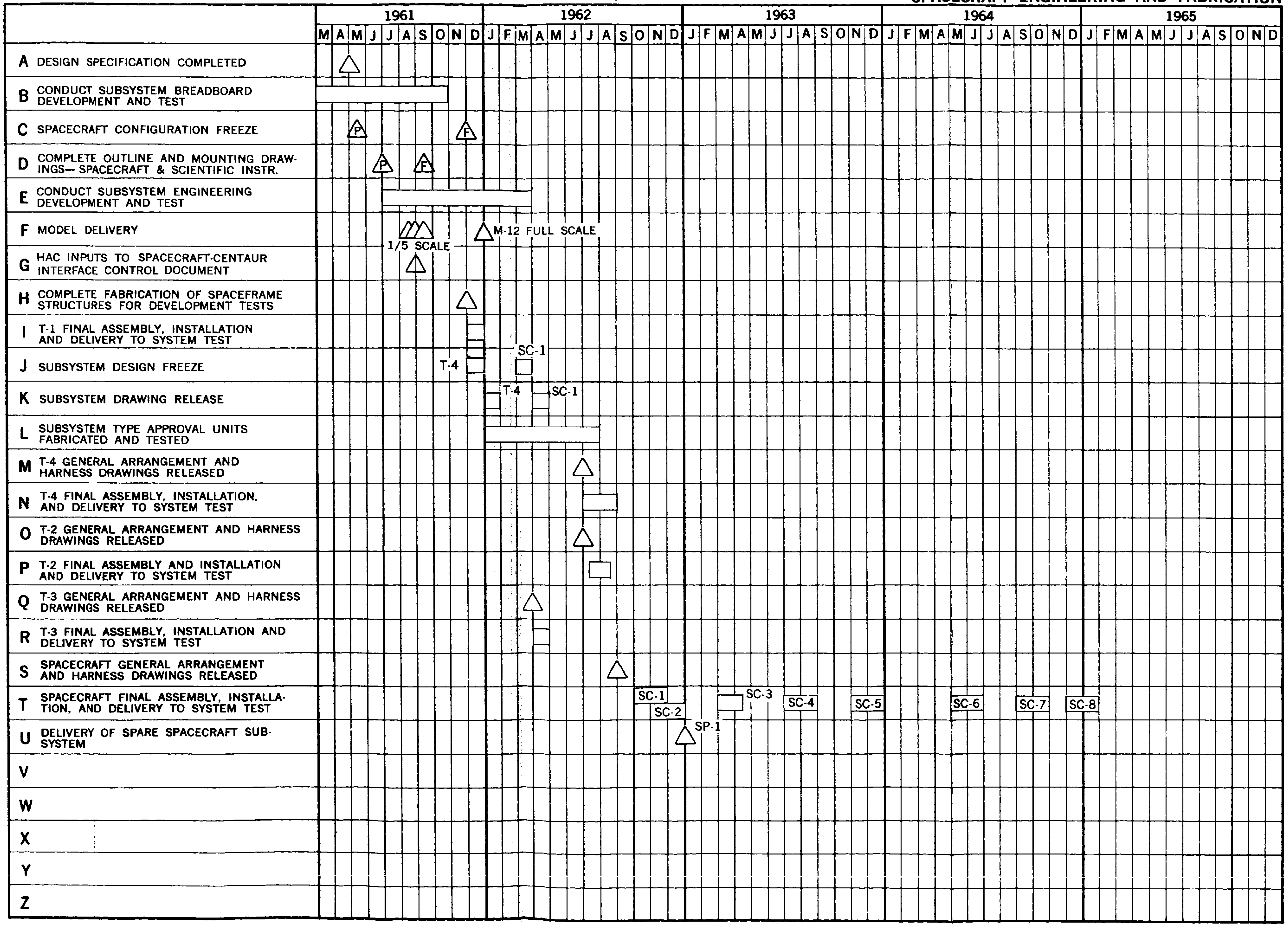
The program presented here takes cognizance of the design capability of the basic spacecraft to carry all of the List I instruments referenced in the design specification,* subject only to weight and balance constraints. The programming is based upon a 2500-pound spacecraft with scientific payload selected by JPL from List I so as to provide three spacecraft containing identical units for each pair of launches (i. e., the first matched pair will be Spacecraft No. 1 and 2 with Spacecraft No. 3 as the stand-by vehicle).

At the completion of the first two spacecraft launches, the remaining spacecraft will be returned to Hughes, Culver City, for upgrading and verification testing of the instrument configuration for the second two launches. In this

* JPL design specification 30240

SURVEYOR SPACECRAFT SYSTEM MASTER DEVELOPMENT, TEST, AND OPERATION PLAN

SHEET #1— SPACECRAFT ENGINEERING AND FABRICATION



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SURVEYOR SPACECRAFT SUBSYSTEM ALLOCATION

SUBSYSTEM	SPECIAL CONFIGURATIONS AND PROTOTYPE *							FLIGHT CONFIGURATIONS										TOTAL
	T-1	T-2	T-2-SP	T-3	SUPPORT	T-4	TYPE APPROV.	RELIAB.* RQMTS. †	SP-1	SC-1	SC-2	SC-3	SC-4	SC-5	SC-6	SC-7	SC-8	
ELECTRONICS A. RADAR ALTITUDE MARKING						1	1	1	1	1	1	1	1	1	1	1	1	10
B. ANTENNA: OMNI-DIRECTIONAL PLANAR ARRAY						1	1		1	1	1	1	1	1	1	1	1	9
C. ALTIMETER RADAR, DOPPLER VELOCITY SENSOR AND ANTENNA		1(a)	1(a)		2	1	1	1	1	1	1	1	1	1	1	1	1	10
D. SIGNAL PROCESSING, TAPE RECORDER AND COMMAND DECODER					2	1	1		1	1	1	1	1	1	1	1	1	9
E. TRANSMITTER AND DIPLEXER ASSEMBLY						1	1	2	1	1	1	1	1	1	1	1	1	11
F. RECEIVER AND TRANSPONDER (2 Each per Set)						1	1	3(b)	1	1	1	1	1	1	1	1	1	9
G. TV: DECODER AND PROCESSOR CAMERAS 1, 2, 3, 4						1	1	1(b)	1	1	1	1	1	1	1	1	1	9
H. SCIENTIFIC INSTRUMENT AUXILIARY ELECTRONICS						1	1		1	1	1	1	1	1	1	1	1	9
FLIGHT CONTROL A. ATTITUDE CONTROL SYSTEM		1	1	1(b)		1	1	1(b)	1	1	1	1	1	1	1	1	1	9
B. SENSOR GROUP (c)		1	1			1	1		1	1	1	1	1	1	1	1	1	9
1. CANOPUS SENSOR					2	1	2	2	1	1	1	1	1	1	1	1	1	11
2. INERTIAL REFERENCE UNIT		1	1		3	1	1	1(b)	1	1	1	1	1	1	1	1	1	9
3. FLIGHT CONTROL COMPARTMENT AND UNITS (d)		1(b)	1(b)			1	1	1(b)	1	1	1	1	1	1	1	1	1	9
PROPULSION A. VERNIER ENGINE SYSTEM		1	1	1	2	1	2			1	1	1	1	1	1	1	1	8
B. RETRO ROCKET ENGINE	1 empty			2 1 inert	21	1 inert	16	3(e)	1	1	1	1	1	1	1	1	1	12
POWER SOURCES A. SOLAR PANEL					2	1	1	1(b)	1	1	1	1	1	1	1	1	1	9
B. BATTERY SETS					8	2	5	1	4	2	2	2	2	2	2	2	2	21
VEHICLE DESIGN A. SPACEFRAME ASSEMBLY (f)	1	1	1	1	8	1				1	1	1	1	1	1	1	1	8
B. INTERSTAGE	1			1	5	1			1	1	1	1	1	1	1	1	1	9
MECHANISMS A. SUBSURFACE PROCESSOR						1	2		1	1	1	1	1	1	1	1	1	9
B. SURFACE SAMPLER/SUBSURFACE SAMPLER						1	2		1	1	1	1	1	1	1	1	1	9
C. POSITIONERS AND BOOMS						1	2		1	1	1	1	1	1	1	1	1	9
D. HIGH RESOLUTION TELESCOPE					3	1	2		1	1	1	1	1	1	1	1	1	9

(a) DEVELOPMENT UNIT

(b) NOT A COMPLETE UNIT

(c) INCLUDES CANOPUS SENSOR, ELECTRONICS, IRU, FLIGHT CONTROL COMPARTMENT

(d) INCLUDES INERTIA SWITCH, SUN SENSOR, EARTH/MOON DETECTOR, ACCELEROMETER

(e) ONE MOTOR OF EACH BATCH OF FOUR FIRED AT THIOKOL

(f) INCLUDES LANDING GEAR AND WIRING HARNESS

* SINCE PROTOTYPE, TYPE APPROVAL, AND RELIABILITY ITEMS OCCUR DURING EARLY PHASES OF DEVELOPMENT, QUANTITIES LISTED ARE NECESSARILY TENTATIVE AND NOT CONTRACTUALLY BINDING. ANY CHANGES TO THIS SCHEDULE WILL BE REFLECTED IN THE MANAGEMENT CONTROL REPORT OR PERT ANALYSIS.

† SYSTEMS RELIABILITY TESTS IN ADDITION TO THOSE PERFORMED AT THE SUBSYSTEMS LEVEL.

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manner an identical spacecraft will be provided as a stand-by for the second two launches. In the same manner the spacecraft remaining from the second pair of launches will be returned to Hughes, Culver City, for necessary instrument updating and systems testing. This spacecraft will then provide spare backup for the third launch pair. It is not intended that the remaining launch (P-48) have an identical backup unit.

Major spacecraft subsystems are identified and their allocation presented in the following table. The purpose of this table is to provide visibility as to the disposition of all of the major subsystems and indicate the spares provisioning employed. Breadboard and development units are excluded from the tabulation.

3. Master Test Plan

An integrated test plan has been devised which includes:

- Components and materials qualification tests
- Detailed exhaustive tests of each unit during the design development phase
- Functional, environmental, and reliability tests of prototypical subsystems to verify design capabilities and to prove operability for the transit and lunar operations
- Series of special systems tests
- Functional, environmental, and flight acceptance tests of spacecraft prior to delivery to AMR

Four test spacecraft are planned (T-1 to T-4). The essential features of each of these systems are as follows:

Two Systems for Simulated Load Tests (T-1 and T-3). To check the load environments of Centaur boost, spacecraft retro, and spacecraft touchdown, two systems are required. A simplified spaceframe and landing gear, T-1, will be tested during the first 6 months of 1962 to check separation characteristics and touchdown dynamics. The mechanical and dynamic simulation model, T-3, will be used for propulsion and structural test. Progress on this test vehicle is traced through the final assembly and test as follows. During March of 1962 the spaceframe and vernier engine are integrated and test-fired at the propulsion subcontractor's facilities. During the month of April final assembly is accomplished, and engineering instrumentation is installed on this vehicle. In May the engineering instrumentation is checked out and calibrated in the systems laboratories. During June the vehicle is shipped to the AEDC test facility, installed in appropriate fixtures, and instrumentation rechecked. Actual performance tests of the retrorocket and vernier engines are to be accomplished during June in the J-2 high-altitude test tunnel. At the completion of these tests the vehicle is returned to Hughes, Culver City, for any necessary instrument or unit upgrading and is then shipped to the General Dynamics, Astronautics, Sycamore Canyon test facility. Instrumentation is checked, calibrated, and integrated with GDA equipment for approximately a month and is then installed upon a Centaur vehicle for static firing tests. During the Centaur static firing tests the spacecraft, including a live retro-rocket engine, will be subjected to the vibration spectrum of boost. The rocket engine will later be inspected and test-fired at the propulsion subcontractor's facility to determine whether any vibration damage has been incurred.

Flight Test of Prototype Control System (T-2). The flight control system performance and dynamics will be confirmed on this basic spaceframe with prototype lunar radar, simplified guidance and control system, and vernier rocket engines. Weight and performance parameters will be modified to simulate the lunar environment. This vehicle will undergo the same vernier engine-spaceframe performance tests at the propulsion subcontractor's facility as T-3. However, T-2 will contain a prototype vernier engine rather than the development model used in T-3. The month-long final assembly cycle of T-2 will be accomplished followed by 1-1/2 months of subsystem and system checkout testing. The T-2 test vehicle plus appropriate portions of the STEA will be shipped to AFMDC for tethered velocity and attitude control tests. It is anticipated that the preliminary instrumentation, telemetry, equipment checkout, and calibration consume the first month at AFMDC with the remaining month and a half for a comprehensive series of flight tests to confirm analysis and laboratory tests of the flight control-electronics-propulsion subsystems interaction.

Prototype Spacecraft System (T-4). To maximize systems testing on non-flight spacecraft, a prototype system has been developed to confirm system design prior to test of flight systems. The T-4 vehicle is an exact prototype of the 2500-pound spacecraft with the scientific instrument payload assigned for Flights No. 1 and 2 (Spacecrafts No. 1, 2, and 3). Prior to final assembly the vernier propulsion system and spaceframe are integrated and tested at the propulsion subcontractor's facility. The assembly is then returned on 1 July 1962 for the 2-month final assembly, installation, and integration cycle. The T-4 vehicle is made up of flight-accepted subsystems which are of the same quality as intended for Spacecraft No. 1. However, the systems do not have the full confidence factor of a flight unit since the type approval tests on various subsystems may not have been completed at this time. At the completion of final assembly, T-4 undergoes a 2-month system checkout in the test laboratory followed by a 3-month environmental test routine. T-4 is then shipped along with an STEA and appropriate ground equipment to AFMDC for full-scale spaceframe coupling tests. These tests are intended to confirm that no deleterious spaceframe, servo, or vibration interactions with the flight control system will be encountered. Next, T-4 is returned to the systems laboratories for 3 months of real time mission sequencing tests. The purpose of these tests is to simulate the launch, transit, and lunar operations of the spacecraft and scientific instrument payload. The complete lunar operations sequence will be accomplished during which the CDC/DSIF will command the spacecraft to perform, in real time, all of the lunar experiments under a simulated lunar environment. All of these tests will be completed in advance of the first spacecraft launch.

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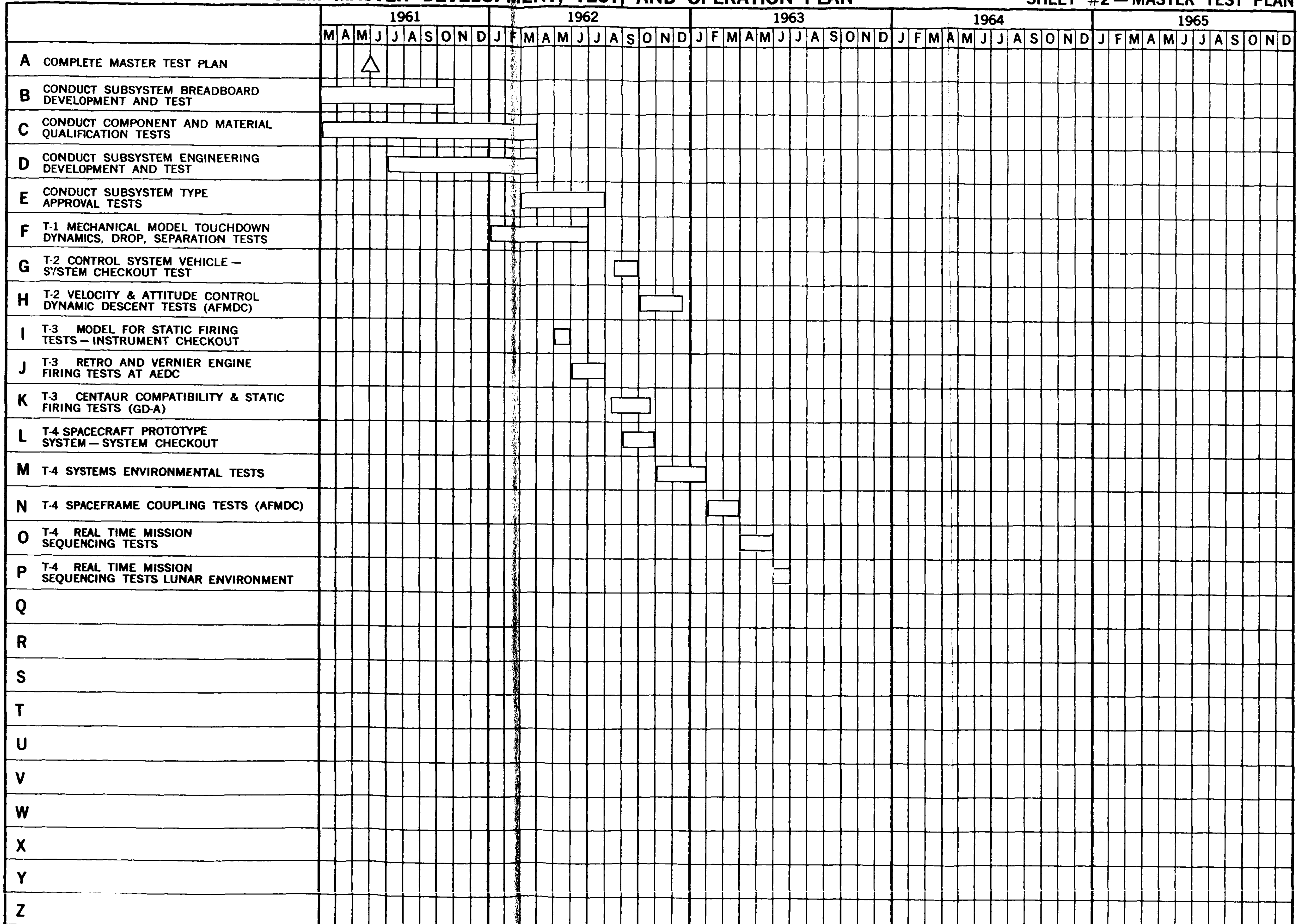
SURVEYOR SPACECRAFT SYSTEM MASTER DEVELOPMENT, TEST, AND OPERATION PLAN

SHEET #2 — MASTER TEST PLAN



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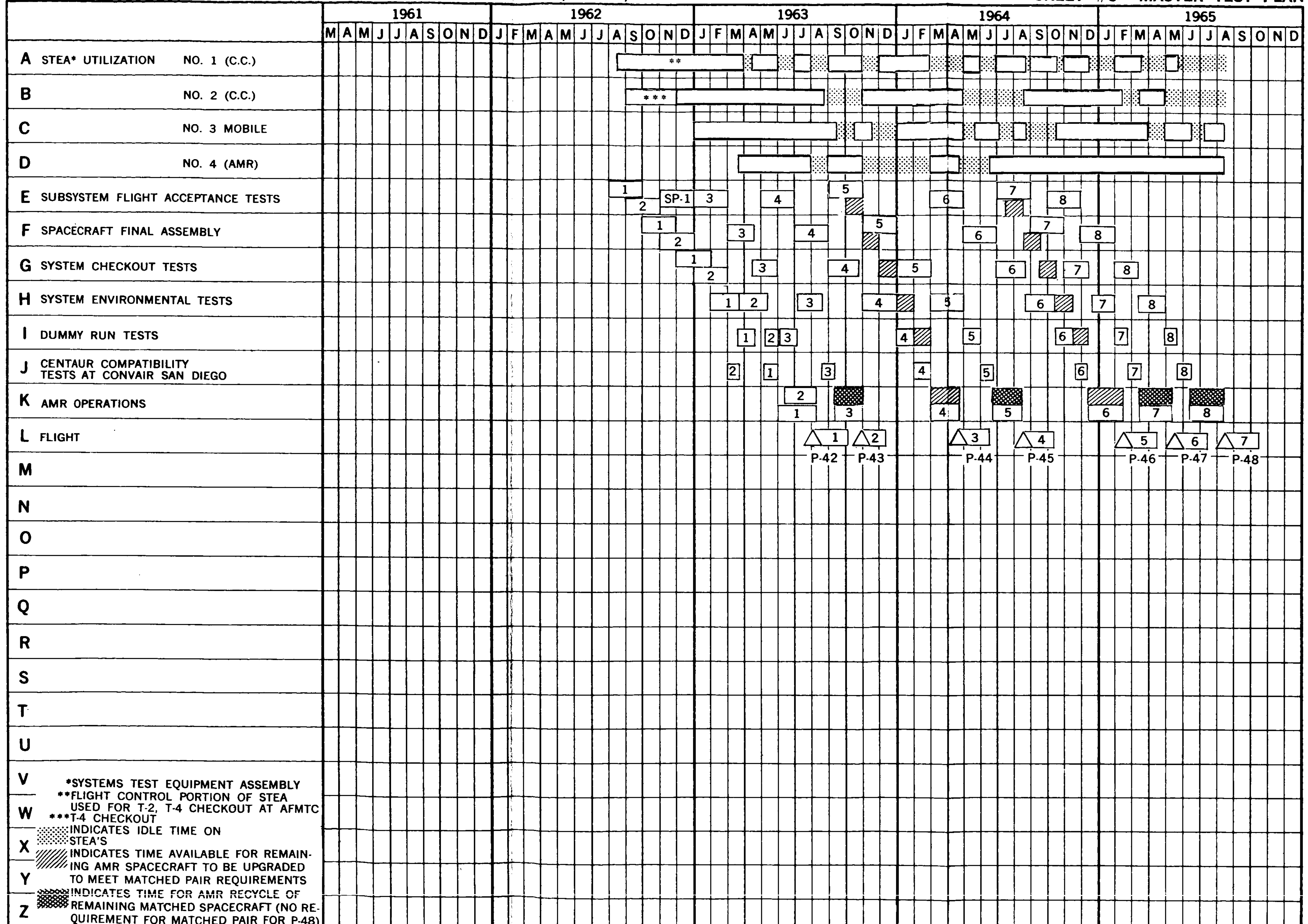
SURVEYOR SPACECRAFT SYSTEM MASTER DEVELOPMENT, TEST, AND OPERATION PLAN

SHEET #3 — MASTER TEST PLAN



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RF Compatibility of Centaur/Surveyor. During the first quarter of 1963, SC-2, the first spacecraft planned for the General Dynamics, Astronautics facility dummy run, will undergo an RF compatibility test in conjunction with the Centaur vehicle.

Four Sets of Systems Test Equipment Assemblies. In order to perform the systems tests effectively, four sets of systems test equipment assemblies (STEA) will be provided. The STEA also includes a Control and Data Handling Console (CDC) to enable simulated transit and lunar operations checks, as well as providing an RF link for communications with the spacecraft. Two of these sets will subsequently be shipped to AMR to serve as part of the ground support equipment during the prelaunch checks at that facility. Additionally, provisions have been made to check the compatibility of each flight spacecraft with its actual Centaur launch vehicle at GDA prior to shipment to AMR.

4. Master Missions Operations Plan

The principal effort in missions operations for the first year is that of detailed planning for the AMR launch and the DSIF operations. A schedule of the documents developed during this period is given in the initial part of this plan. Each of the STEAs will contain a CDC representative of that which is installed in each of the DSIF stations. The allocation for the command and data handling consoles is as follows:

One set for Goldstone DSIF

One set for Woomera DSIF

One set for Krugersdorp DSIF

Appropriate portion of four sets for use in STEAs

The CDC will be checked for compatibility with the DSIF at the Goldstone facility at the end of 1962. The installation at the overseas stations is scheduled so that mock operations can take place 2 months prior to the first launch. Utilization of the DSIF after each launch is also scheduled. This is based upon a 24-hour day use for the first 15 days and a 16-hour day for 75 days thereafter.

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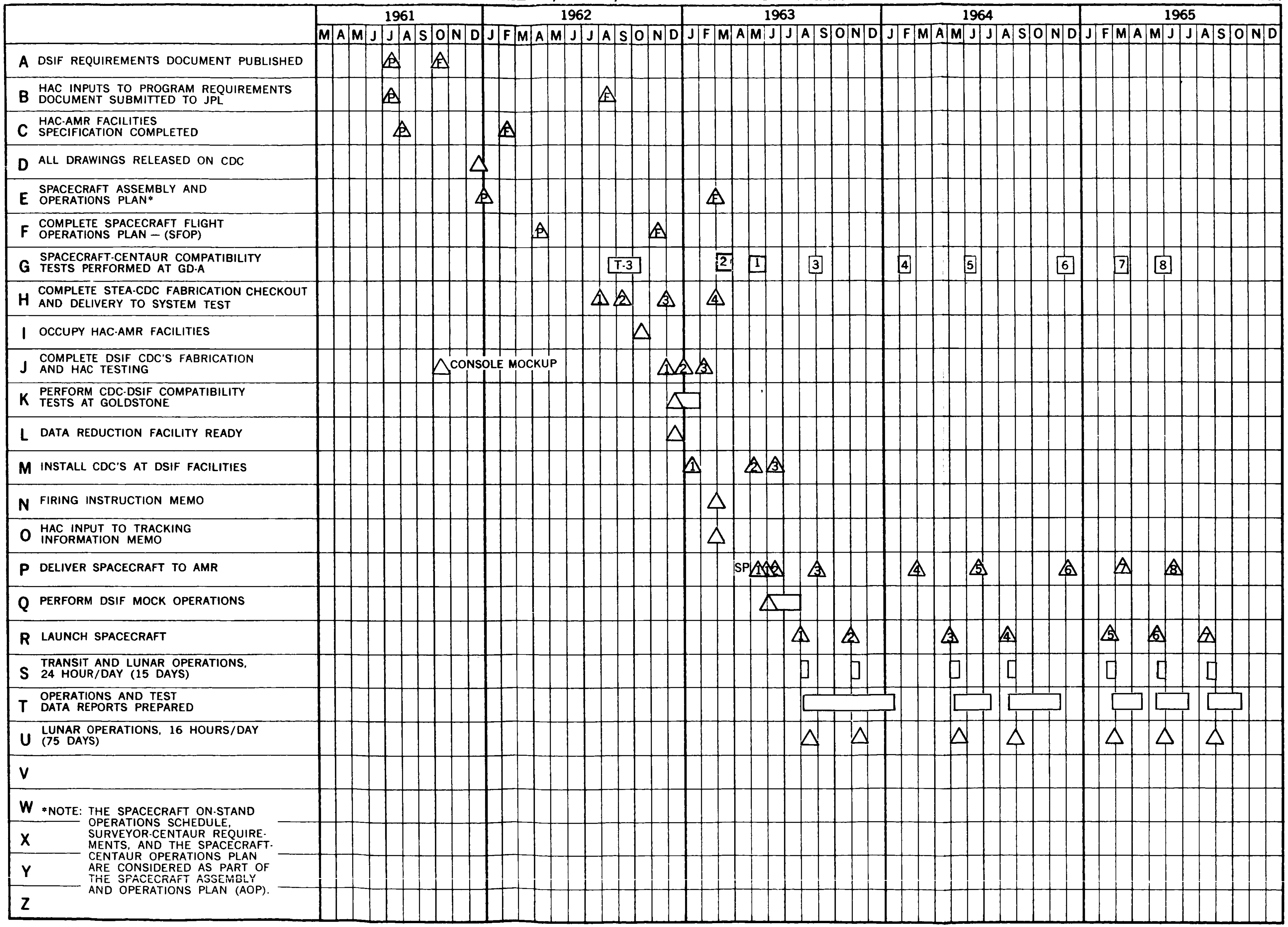
SURVEYOR SPACECRAFT SYSTEM MASTER DEVELOPMENT, TEST, AND OPERATION PLAN SHEET #4 — MASTER MISSIONS OPERATIONS PLAN



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MASTER PHASING PLAN FOR SURVEYOR SPACECRAFT SYSTEM

The time phasing for the spacecraft system is presented in the accompanying Master Phasing Plan. The purpose of this plan is to show in summary form an overview of the entire Surveyor spacecraft development program and the interrelations of the various tasks and key milestones necessary to conduct the program. This chart shows (1) the major end items which will be produced to meet program requirements and (2) the major program tasks and milestones involved in the spacecraft system development.

Since the Master Summary has briefly described spacecraft engineering and fabrication, test, and missions operations, this section will outline the effort being applied to the program in each of the technical areas. Task descriptions of the fourteen major elements of the Surveyor spacecraft project follow.

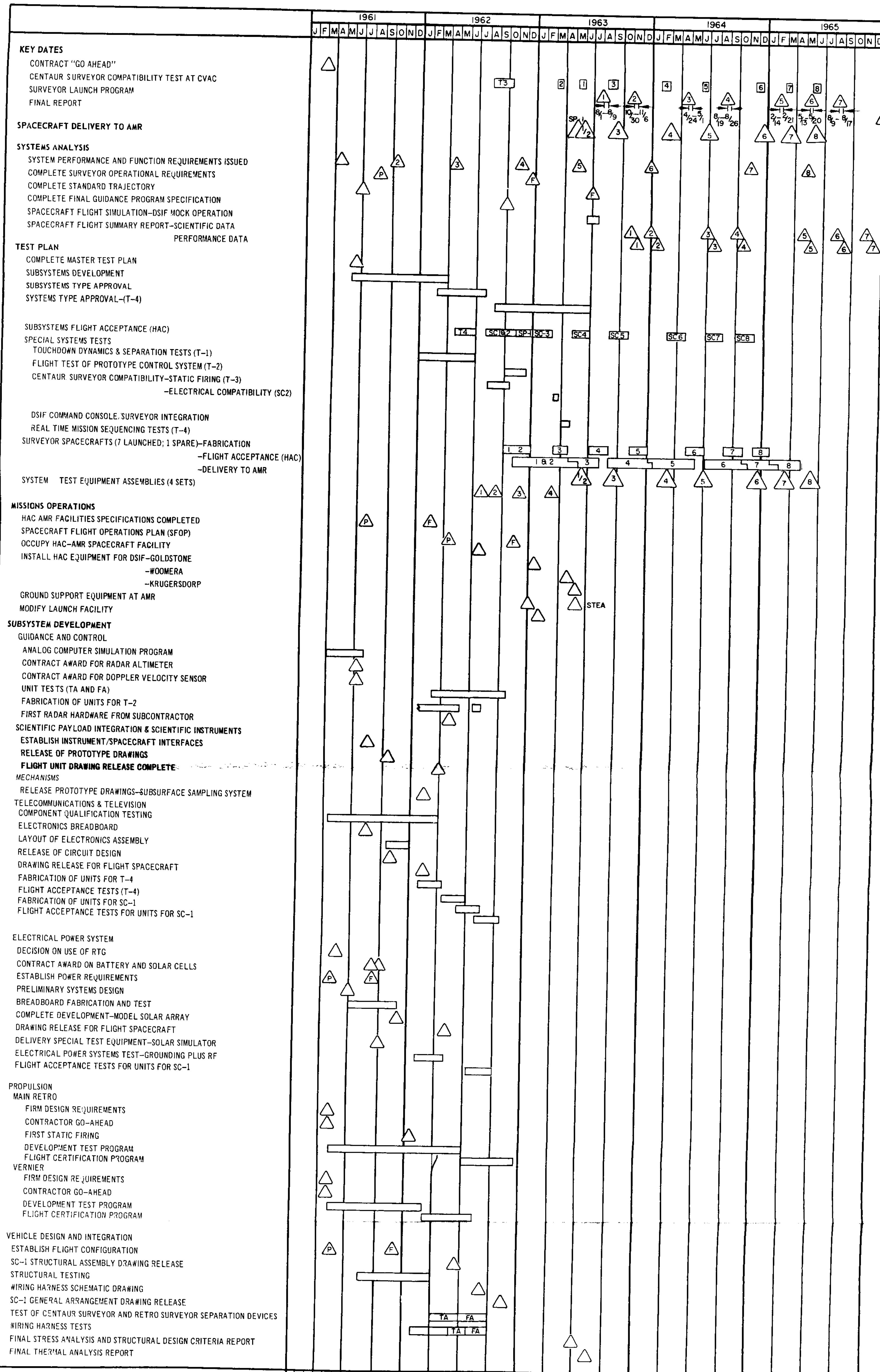
1. MANAGEMENT

This task encompasses the over-all project management, direction, and control for the Surveyor spacecraft program. It includes the coordination and alignment of the appropriate company effort to the project. It provides the liaison with JPL and the other participating agencies of the Surveyor program. It is within this task that the tools for project control exist. The project programming, the Program Evaluation and Review Technique (PERT) method of program control, the cost control, and subcontract control are included in this item. Because of the importance of drawing change control, power control, and weight control to Surveyor, these functions are also considered a part of management.

2. DOCUMENTATION

The documentation includes the mechanics of editing, printing, reproducing, and distributing both the internal and external drawings and reports for the Surveyor project. After the inputs are received from the technical areas, the responsibility for processing into finished form resides in this function. It also maintains a Surveyor Document Center and other pertinent records and files. Film reports, special models, and other displays are included as part of the responsibility of this task.

MASTER PHASING PLAN



SUBSYSTEM DELIVERY SCHEDULE FOR QUALIFIED ASSEMBLIES

SYSTEM	DATE
T-4	7-1-62
SC-1	10-1-62
SC-2	11-1-62
SC-3	3-1-63
SC-4	7-1-63
SC-5	11-1-63
SC-6	5-1-64
SC-7	9-1-64
SC-8	12-1-64
SPARES (1 SET)	1-1-63

T-1	MECHANICAL MODEL FOR TOUCHDOWN DYNAMICS AND SEPARATION
T-2	FOR FLIGHT TEST OF PROTOTYPE CONTROL SYSTEM (SIMPLIFIED SPACEFRAME, BREADBOARD GUIDANCE AND CONTROL, NONQUALIFIED LUNAR RADAR)
T-3	WITH DYNAMIC AND MECHANICAL SIMULATION FOR STATIC TEST AT AEDC AND FOR CENTAUR SURVEYOR COMPATIBILITY TEST AT CVAC
T-4	PROTOTYPE NON-FLIGHT SYSTEMS SPACECRAFT
SP-1	SPARES (UNITS)
SC-1, -8	FLIGHT SPACECRAFT

LEGEND
P - PRELIMINARY
F - FIRM
TA - TYPE APPROVAL
FA - FLIGHT ACCEPTANCE

8-7-61

3. SYSTEM ANALYSIS

- Guidance and Trajectory Analysis

This task covers that work necessary to supply basic trajectory and guidance information for Mission Analysis and to JPL. Post injection, guidance, and terminal descent programs will be designed and utilized. The JPL orbit determination will be studied to supply information necessary for mission operations, injection, terminal descent system, midcourse fuel, and landing accuracy specifications.

Using preliminary Centaur performance information, supplied by JPL, standard trajectory information will be generated for all planned launch months. As new Centaur performance data become available, refined standard trajectories will be run. Preflight standard trajectories will be supplied one month prior to each actual mission.

The standard lunar trajectory program will be used to perturb trajectories and obtain basic guidance parameters necessary for the study and design of midcourse guidance and for the determination of midcourse fuel requirements.

To ensure compatibility between the preinjection trajectory, the boost guidance system and the lunar transit trajectory and midcourse correction capability, a study will be made, with the cooperation of General Dynamics Astronautics and Marshall Space Flight Center, of Surveyor preinjection trajectories. Methods for specifying injection conditions which are required for Surveyor missions and are compatible with the Centaur System will be studied and coordinated with JPL, MSFC, and Astronautics.

Technical assistance will be supplied to Mission Operations for guidance and orbit determination decisions required for each mission.

- Spacecraft System Requirements

This task covers that work necessary to establish and maintain current the Surveyor spacecraft system performance, functional and test requirements.

Taking account of JPL basic requirements, subsystem interactions, and design trajectory information, system performance and functional requirements will be specified for the major spacecraft subsystems such as flight control, descent radars, and propulsion. An interaction matrix relating cross-correlated requirements among the spacecraft subsystems will be developed to aid in the control and establishment of system design parameters.

In order to ensure adequate performance evaluation and transit mission fault isolation, methods for system performance evaluation will be studied and system engineering data requirements established. Existing subsystem engineering data will be reviewed and used wherever possible to perform the system evaluation.

System test requirements and conditions necessary to establish proof of system performance will be determined and supplied to the System Test and Reliability Activity.

- Mission Analysis

Responsible for establishing system operational requirements and constraints on launch, landing, and scientific data processing. Utilizing standard trajectory information supplied by the Guidance and Trajectory Section and deep space instrumentation characteristics supplied by JPL, specific operational requirements for time, tracking acquisition, and tracking data rate will be determined and supplied to Mission Operations. These investigations will supply data input for a study on operational limitations for transit performance. Correlation of landing coordinates with known lunar surface features will be carried out so that desired landing areas may be logically selected for each mission.

Scientific instrument performance and objectives will be studied to determine confirmation, calibration, and potential data processing requirements in terms of correlation of necessary auxiliary data, critical conditions, data rate, and total magnitude of data necessary for real time (quick look) processing and display.

Transit tracking and engineering data requirements will be considered with the results of the scientific instrument data processing investigation to complete an over-all operational study and establish firm requirements and limitations on spacecraft sequence, sequence flexibility, data transmission, priority of transmission, real time reduction, and display. Perturbations of the normal lunar operational sequence will be studied, considering basic system limitations such as power, life time, reliability, and such operational factors as missions remaining to analytically design and specify emergency modes of operation.

Technical assistance on interpretation of lunar operations and approval of data for release will be provided by this activity to Mission Operations.

4. SCIENTIFIC PAYLOAD INTEGRATION

This task involves the mechanical and electrical integration design of the scientific instrument payload onto the Surveyor spacecraft, specification and evaluation of system tests for type approval and flight acceptance.

The basic instrument requirements are determined by JPL, whereas the above-described instrument/spacecraft interfaces are determined jointly by JPL and Hughes.

Detailed design requirements for the instrument deployment and manipulative gear and the integrating electronic units are determined.

Test programs will be laid out to demonstrate proper function of the spacecraft-instrument configuration in an integrated sense, and monitoring and evaluation of the tests will be performed.

Close liaison with JPL and the instrument developers will be carried out to ensure proper and timely design information interchange.

5. ELECTRONICS

Under this general task heading is grouped the responsibility for all spacecraft electronics systems except for development of circuits directly associated with the flight control system. Included is responsibility for the following: High-Gain Antenna, Omnidirectional Antenna, Signal Processing, Command Decoding, Transmitters, Receivers and Transponder Interconnections, Spacecraft Television, Power Management (including electrical conversion and power switching), Altitude-Marking Radar, Antenna Diplexing and Switching System. Also included is responsibility for engineering management of electronics subcontracts. Major subcontracts include: Tape Recorder/Reproducer, Radar Altimeter, Doppler-Velocity Sensor.

For the in-house electronics the development cycle proceeds generally by the following phases: concept; block diagram; breadboard development; preliminary circuit release; final circuit release; preliminary packaging design; final packaging design; prototype hardware development; prototype unit fabrication; acceptance testing; flight unit qualification; flight unit fabrication; acceptance testing and delivery; system test support and follow-up. Formal and informal design reviews of electronic units, the interfaces between electronics units, and the interface between the electronics systems and the remainder of the spacecraft are introduced at suitable points in the development cycle. Flight control electronics development responsibility becomes a part of this task at the time at which unit packaging design begins. Electronics accepts prime power from solar cells from Electrical Power Sources and distributes and converts this power to a form suitable to the spacecraft subsystems. Electronics also accepts power from and provides charge control to the batteries provided by Electrical Power Sources. Electronics provides functional (but not mechanical) requirements to the Mechanism's activity for TV actuators and telescope optics and for high-gain antenna actuators. Electronics is responsible for obtaining radars suitable for meeting Flight-Control Systems functional requirements.

Electronics subcontracting procedures include the following time-phased steps: definitize concept, establish functional requirements, prepare Product Specifications, furnish information to guide Subcontract Steering Committee, assist in preparation of Statement of Work, assist in briefing of potential subcontractors, supply technical representation on proposal evaluation team, assist in final negotiations with successful bidder, take responsibility for technical and cost performance of subcontractor throughout life of subcontract.

6. FLIGHT CONTROL SYSTEM

The flight control subsystem is that part of the spacecraft system which functions to provide velocity and attitude control during transit. The task encompasses system design; equipment development, fabrication, and test; and subsystem test.

Equipment to be developed includes optical sensors consisting of a star tracker, primary and secondary sun sensors, and an earth/moon detector, inertial reference unit consisting of three strapped-down gyros and an accelerometer, attitude controls consisting of a gas jet equipment and a roll actuator, and flight control electronics. All equipment exclusive of the attitude controls and the secondary sun sensor will be packaged in an integral, field-replaceable assembly with self-contained provisions for thermal control. Type approval tests are conducted on prototype models of the individual units and on the sensor group assembly. Flight acceptance tests include closed-loop tests of the sensor group assembly on the three-axis space simulator.

Functional design verification of the coast phase attitude control subsystem is performed using engineering models of the equipment on the space simulator. A special flight test vehicle (T-2), employing lunar radar, vernier engines, and inertial instruments, is used to verify the design of the terminal phase vernier control system. The proof test model spacecraft is used to demonstrate control loop stability with vernier engines running in a static attitude control test.

7. PROPULSION

This task has the responsibility to provide propulsion systems for the Surveyor spacecraft. It exercises technical management over the two subcontracts relating to Surveyor propulsion requirements. These two contracts are:

- The design, development, and delivery of the vernier propulsion system
- The design, development, and delivery of the retro-rocket engine

In carrying out this responsibility the following functions are performed:

- Detail specifications for the propulsion system are determined to fulfill spacecraft performance and environmental requirements. In conjunction with the subcontractors, a development, fabrication, and test program is established.
- Provision of management and technical guidance to the subcontractors.
- Coordination with all other Surveyor activities to ensure compatibility of the spacecraft and its associated propulsion systems.

- Provide technical support during test and mission operations.
- Review and maintain a survey of progress in propulsion technology so that improvements may be incorporated into the design, development, and tests of the Surveyor propulsion system.

8. ELECTRICAL POWER SOURCES

The design, development, fabrication, and testing of the primary electrical power sources for the Surveyor spacecraft are carried out. The primary power sources, consisting of an oriented photovoltaic solar array and rechargeable silver-zinc batteries, provide a coarse regulated voltage. Breadboard and development tests are performed to verify the power system design.

The battery is procured via subcontract to a battery manufacturer and its development is directed and monitored. All testing, Type Approval, Flight Acceptance, and Battery Acceptance, is accomplished by Hughes. A comprehensive reliability program will be instituted to assure the required performance of the battery.

Design and assembly of the solar panel will be based upon breadboard, development, type approval, and reliability testing. Flight Acceptance Tests shall be conducted on each solar panel.

Complete Quality Control procedures will be in effect, both at the subcontractors and at Hughes, during all phases of the program.

Integrated electrical power system tests will be conducted to assure reliable operation of the complete spacecraft during all phases of the Surveyor Mission.

9. VEHICLE DESIGN AND INTEGRATION

This task includes the configuration design, general arrangment, detailed design, and drawing preparation of the main mechanical elements of the spacecraft vehicle. It also includes the fabrication and tests of most of the mechanical elements of the spacecraft system. The task is defined as follows:

- General Arrangement Design

  Included in this activity are the studies necessary to develop the general arrangement, equipment mounting interfaces, and configuration envelope definitions for both flight and test spacecraft. Kinematics studies to assure stowed and manipulative compatibility among the various subsystems to be mounted on the spacecraft are performed. The detailed kinematics of the high-gain antenna and solar panel assembly are analyzed and correlated with the geometric requirements established by landing site locations, lunar surface contours, and earth-moon libration and declination combinations. As a part of the design process, it is required that effective weight and balance analyses be conducted to provide center-of-gravity control both vertically and laterally. The arrangement, mounting, and electrical interconnection of subsystems located within equipment compartments A and B are also accomplished in this activity.

- Detailed Design

  All of the detailed drawings necessary to accomplish fabrication and quality control of both flight and test spacecraft are prepared. Detailed weight and balance reports are developed and related detailed assembly drawings are generated in concert with the detailed design specifications, which are based on the functional requirements for the spacecraft system. Included in this function are the preparation of the various wiring harness and interconnection descriptions necessary for the preparation of the various harnesses required for flight use. The detailed design of the mechanical elements of ground handling equipment needed to perform weight and balance, optical alignment, spacecraft assembly, spacecraft hoisting functions, and to provide satisfactory shipping protection are accomplished here.

- Fabrication

  The fabrication and subsystem test of the following units are included for both test and flight spacecraft:

  * Spaceframe Assembly
  * Landing Gear Assembly and Extension Mechanism
  * Retro-Engine Separation Mechanism
  * Equipment Compartments A and B

* Spacecraft/Centaur Adaptor Structure

* Spacecraft/Centaur Separation Mechanism

* Spacecraft Wiring Harnesses

* Fabrication and Maintenance of Spacecraft Mockups, Both Full Scale and Reduced Scale

The fabrication and test of the mechanical ground handling equipment necessary to accomplish weight and balance determination, optical alignment, system assembly, hoisting functions, and to provide adequate protection during shipment are included.

- Assembly and Integration

The physical mounting of each of the subsystems to the spaceframe and electrical and manipulative interconnections required for spacecraft operation are accomplished in this activity. The determination of the weight, balance, and mechanical and optical alignment of each of the subsystems is included during this process. The reports necessary to transmit this information to systems test and missions operations activities are prepared for movement with the spacecraft during subsequent activities. Also included is the preparation of instructions on weight, balance, and alignment procedures for use by systems test and missions operations functions. This activity will also supply the engineer,technician, crew chief, and mechanic support for both the systems test and mission operations.

10. ENGINEERING MECHANICS AND THERMAL CONTROL

This task involves the analytical design and determination of design criteria for the spacecraft structure, landing gear, and thermal configuration consisting of the following:

- Structural Criteria, Analysis and Test

Structural design criteria for the spacecraft vehicle resulting from static and dynamic loads during handling, boost, retro, and touchdown are determined and specified. Structural dynamic analyses are conducted to determine vibration levels transmitted through spaceframe and interconnect structure to spacecraft components. Stress and deflection analyses are performed on all spacecraft structures to define critical loading conditions and structural reliability and to recommend structural changes. As confirmation and extension of the analyses, static and dynamic tests of spaceframe, interconnect, landing gear structural components, and spacecraft mounting structure are performed, evaluated, and reported. Landing gear drop tests are performed. Structural design criteria and stress analysis and test reports are prepared.

- Touchdown and Separation Dynamics

An analytic design of the landing gear system is generated and evaluations are made of the touchdown stability performance and resulting loads for various touchdown and lunar surface conditions. This area has the technical responsibility in the subcontract procurement of the landing gear shock absorbers. The modeling and test requirements for landing gear drop tests are established and the results evaluated and reported. The analytical design and test parameters are specified for the Surveyor/Centaur and Surveyor/retro-rocket separation. Touchdown and separation analysis reports are prepared.

- Thermal Control

Thermal control involves analytical design, evaluation, and testing of all major thermally active and passive spacecraft components. A unified thermal test program of all spacecraft units will be conducted by this activity. Hardware procurement responsibility is limited to thermal switches. Development and type approval test programs are established, conducted, and evaluated. The thermal environment of all spacecraft components is defined and documented for all phases of spacecraft operation. Thermal analysis reports are prepared.

11. MECHANISMS

This task is responsible for the design and fabrication of the spacecraft subsurface sampling and processing system, antenna/solar panel positioner, instrument placement, TV mirrors and high-resolution telescope, anchoring and pyrotechnic devices (electric squibs, explosive pin pullers, etc). The subsurface sampling and processing system will drill a hole and obtain samples from beneath the lunar surface, prepare the samples for analysis, and deliver them to the gas chromatograph, X-ray spectrometer, and X-ray diffractometer for analysis. The subsurface logging sonde will be lowered into the hole after the drilling operation is completed. The surface sampler will obtain samples of the lunar surface and deliver them to the sample analysis system. The antenna/solar panel positioner elevates and positions the antenna and solar panels. Instrument placement is achieved with booms, spring-driven mechanisms, and cables. Gas-pressurized telescoping extension booms will deploy the lunar atmosphere gauge, plasma probe, radiation detector, surface geophysical packages "A" and "B", and the omnidirectional antennas. The acoustic source and the separate acoustic sensors, as well as the penetrometers and the thermal diffusivity package, will be placed on the lunar surface with the spring-driven mechanisms. The seismometer will be lowered gently to the lunar surface by means of a velocity-controlled cable and a shield will be deployed around it. The magnetometer will be remotely deployed by a spring-actuated device. Mirrors, which are located in a shroud above the television cameras, will tilt and pan thereby serving to move the viewing field of the cameras so that the cameras can remain stationary. Normally the mirrors remain in a closed position within the shroud which protects the camera lenses and the mirror reflecting surface from lunar dust. A telescope with adjustable focus will provide extra-high resolution viewing. The anchors, consisting of propellant-driven spikes located on each vehicle leg, will anchor the spacecraft to the lunar surface. This task is also responsible for the qualification of the electrical squibs used throughout the spacecraft in valves, explosive latch pins, acoustic source, boom pressurization source, etc.

12. SCIENTIFIC INSTRUMENTS

Hughes will provide technical support in the scientific instrument development area at JPL direction until 7 November 1961. At that time the remaining development responsibility, as well as procurement responsibility for prototype and flight instruments, will be transferred to Hughes.

13. RELIABILITY AND SYSTEMS TEST

- Quality Assurance and Sterilization Program

This task has two principal and related objectives: To minimize the possibility of error in the fabrication and checkout phases of the spacecraft preparation, and to guarantee the sterility of the vehicle prior to launch. Both tasks must, by nature, be subject to rigorous policing and control, which is to be accomplished by the Quality Control organization subject to methods and procedures, the development of which is the prime purpose of this task.

The present program in the Quality Control area involves development of controlled, detailed inspection and test procedures and the establishment of a manufacturing level quality system for the flight vehicles. Only in this way can adequate insurance be obtained that fabrication, assembly, and test errors are eliminated.

In the Sterilization area, the task scope is somewhat broader, requiring, first, development of a detailed sterilization plan. Subsequently, continuous review of the spacecraft design to assure that the sterilization plan can yield its objective without placing spacecraft reliability in jeopardy is required. New sterilization methods and techniques will be developed as need arises.

- Reliability Program

This task will result in establishing the basic Reliability Design Specifications and Analysis Standards. Subsystem and system reliability models will be developed and mechanized to study effects of changes to elements of these equations. A Reliability Procurement Specification will be developed defining these requirements. A Failure Reporting and Reliability Data Collection System will be established. A Failure Analysis

Board will be established to review each failure, establish causes, recommend action to be taken, and assess the effect of the failure upon system reliability. A Reliability Assurance Testing Program will be established to provide data to assure that minimum levels of confidence of reliability probability are being achieved. Additional units and elements will be utilized where necessary. Participation in Design Reviews will ensure that reliability considerations are being undertaken in each critical area. Surveillance of subcontractors' efforts will be maintained to ensure that appropriate weight is being given to reliable design, materials, processes, reliability testing, and failure analysis. Reliability surveillance will be undertaken throughout the complete system test and mission launch periods to ensure high priority response to field failures for analysis and immediate response.

- System Flight Acceptance Test Program

System flight acceptance tests will be conducted on SC-1 through SC-8 at Hughes and repeated at AMR. In general, the tests are similar to the type approval tests, but are designed to verify product quality while minimizing usage fatigue. All subsystems of each spacecraft will be tested both qualitatively and quantitatively. In the case of some subsystems the quantitative tests are not as rigorous as the type approval tests. To minimize fatigue, the environmental levels to which the spacecraft will be subjected will not exceed those expected in actual spacecraft flight and lunar landing. The flight acceptance tests repeated at AMR will not include the environmental portions of the tests, but will be limited to reverification of the functional integrity of the electronics, mechanisms, controls, and instruments.

- System Test Equipment Design, Fabrication, and Checkout

The System Test Equipment Assembly (STEA) consists of special test equipment which will be used to make systems tests on the Surveyor spacecraft. It will be used to perform system field acceptance tests at AMR, type approval tests, and flight acceptance tests in the systems test laboratory and at the environmental facility. The STEA will consist of electrical test consoles, flight simulation test tables, and special spacecraft vibration and thermal monitoring instrumentation to be used during environmental testing. A Command and Data Handling Console (CDC) will be provided with each STEA. A transmitter and receiver simulating the DSIF will be furnished to close the loop between the spacecraft and the CDC.

The first STEA design task is the establishment of detailed functional requirements. This will be followed by the system design of suitable measurement techniques leading to the development of STEA block diagrams. In order to establish interconnection cable requirements, general test position layouts for each of the test areas will be made. The circuit design task consists of the detailed design of the individual test consoles. In many cases subassemblies such as signal generators, spectrum analyzers, oscilloscopes, and standard meters will be used in the circuit design. Early effort will be focused on the design and procurement of long lead time items such as the transmitter, receiver, antennas, hydraulic flight table, etc. Prior to the completion of each development phase, functional concept, circuit design, packaging design, and design reviews will be held.

- Proof of Design Tests

Responsible for proving the integrity of the total spacecraft design. Testing of the various assemblies and also the complete spacecraft will be performed under conditions simulating as closely as possible environmental conditions somewhat more severe than are expected to be encountered in an actual mission. Special test equipment must be designed, fabricated, and checked out for each test. Test procedures must be written and test data analyzed for each test.

The descent dynamics test (Model T2) functionally checks the complete velocity and attitude control subsystem with the vernier engines during the terminal stage of the vehicle descent.

A static firing test will be performed to determine whether undesirable vibration coupling exists between the inertial attitude reference and the test vehicle frame. Modifications to the attitude control loop will be made, if required, before commencing the dynamic tests.

The test vehicle is suspended from a tethered balloon 1500 feet above the ground, and the vernier engines are started on minimum thrust. For the initial tests, gyro attitude control only will be commanded. The vehicle will then be dropped and the attitude mode data recorded. In later tests after the vehicle's velocity reaches a predetermined value during the attitude control mode, radar control will commence. When the vehicle velocity reaches a still lower value, the control system will maintain this lower value. The test vehicle will be recovered by a snubbing line before it reaches the ground. These dynamic descent tests will be performed with various initial conditions of vehicle attitude and lateral velocity.

The static firing and mechanical compatibility test (Model T3) will be conducted to obtain vibration data on the spaceframe and on the components necessary to confirm design estimates. The spacecraft will be mounted on the thrust stand so that the thrust and roll axes are horizontal and the spacecraft pressure and vibration characteristics will be recorded during firing. The mechanical compatibility test will be conducted with the model placed on the Centaur launch vehicle to demonstrate complete mechanical compatibility between the spacecraft and the launch vehicle, both statically and dynamically, during a Centaur static firing. During the static firing of the Centaur, vibration levels and frequencies, sound levels, and clearances between the spacecraft and the Centaur will be monitored.

The spaceframe coupling test (Model T4) will determine if vibration due to valve or vernier engine operation can be coupled throughout the spaceframe into the control electronics to excite resonances capable of causing erratic operation of the flight control system. The spaceframe coupling test will be conducted by suspending the vehicle from a tower with cables. While suspended, the vernier engines will be fired, the vernier engine valves operated, and the velocity and attitude control subsystem activated. High-speed cameras, angular position transducers, and accelerometers will be used to obtain the required data.

The scientific payload integration test (Model T4) will ensure proper mechanical, electrical, and environmental compatibility of the scientific instruments with the complete spacecraft and determine the operation and compatibility of the scientific instruments with the spacecraft environments. After installation on the spacecraft, the instruments will be checked for functional operation, clearance, placement, etc, to ensure conformance to the instrument specifications. Tests will be performed on the instruments and appropriate spacecraft functions to determine operation and calibration of the scientific instruments in the integrated environment.

- Components and Materials Control Program

Responsible for defining the Standard Parts List for the spacecraft, Will conduct evaluation of "critical" components, processes, and materials for flight approval. Will monitor ABMs for parts application and contribute to design reviews as required. Will provide vendor inspection and surveillance, incoming "critical" parts inspection, and 100 percent inspection where required. Will conduct investigations into alternate materials and processes that apply to the particular requirements of this program. Will conduct reliability analysis of failed parts and materials to assess cause and recommend approaches and alternate components or materials for consideration.

14. MISSIONS OPERATIONS

This task consists of planning and executing the flight experiments of Project Surveyor from the delivery of flight accepted spacecraft in the Hughes Culver City plant to delivery of experimental data and flight test reports to JPL. The operational activities involved include delivery of equipment and spares to AMR and DSIF stations, field checkout of spacecraft and support systems, prelaunch operations on spacecraft at Cape Canaveral, operation of Hughes assignments in DSIF stations and the Surveyor Mission Command Center, data reduction, and test report preparation.

- Planning and Preparation Phase

The principal effort in mission operations during this phase is that of detailed planning for the flight spacecraft/Centaur compatibility tests, AMR launch operations, and DSIF operations.

* To prepare, coordinate, and maintain the Surveyor Spacecraft General Test Plan from general objectives defined by JPL and the Surveyor Systems Analysis Department.

* To determine and document the AMR and GDA/Centaur test and operational facility requirements for spacecraft operations.

* To prepare, coordinate, and submit the required AMR documentation.

* To coordinate Surveyor spacecraft subcontractor field operations.

* To coordinate and define ground handling equipment, transportation, and sterilization specifications that ultimately affect launch operations.

* To determine the requirements for DSIF support of Surveyor operations and present these requirements in the DSIF Requirements Document.

* To design and develop the Command and Data Handling Console (CDC).

* To fabricate, test, deliver, install and checkout a CDC assembly in each of the DSIF stations and provide 100 percent spares.

* To fabricate, test, and deliver four CDC assemblies for installation in the Systems Test Equipment Assemblies (STEA) with required spares.

* To train the DSIF and the STEA operating crews.

* To plan the prelaunch operations of Surveyor spacecraft at Cape Canaveral.

* To design the operationally derived requirements for the Surveyor/Centaur booster vehicle to the Surveyor/Centaur Working Group and designate a representative to this group to assist in preparing a specification for the Surveyor/Centaur vehicle; to coordinate the operational aspects of this specification with JPL, NASA/MSFC, and General Dynamics-Astronautics as required.

* To coordinate launch pad procedures and countdown with NASA/MSFC and GDA.

* To assign a spacecraft senior engineer for the Launch Operations.

● Launch Operations Phase

During this phase the major task will be the responsibility for the execution of all activities related to flight spacecraft operations at Cape Canaveral and GDA. A Senior Engineer-Spacecraft will be designated to represent the spacecraft contractor on the Launch Operations Working Group and act as a staff advisor to the Firing Director during the actual launch operations. In addition, supervision of all Hughes personnel and support equipment required to check out and prepare the spacecraft for launch aboard the Atlas/Centaur booster will be accomplished. The following are the major tasks during this phase:

* To plan and execute the AMR Operations of Surveyor Spacecraft including the prelaunch checkout, final mating to the booster.

* To plan and execute the Spacecraft/Centaur compatibility testing of each flight spacecraft at GDA-San Diego.

- Transit and Lunar Operations Phase

The primary responsibility for the operation of the spacecraft from the time when the booster injects it into a transit orbit to the moon until the lunar surface experiments are completed and the data reduced, is assigned to the Surveyor Spacecraft Laboratory. The Transit and Lunar Operations of Missions Operations is responsible for all aspects of this phase of the flight experiment and will coordinate all Hughes activity in support of the operation. The following are considered to be the major tasks during this phase:

* To assign lunar experiment conductors to supervise all Surveyor project lunar operations and to represent the spacecraft contractor in the lunar experiment working group.

* To prepare and maintain data reduction procedures and sequences.

* To coordinate and prepare the spacecraft flight operations plans for each flight.

* To coordinate Surveyor data processing requirements and be responsible for all Hughes data reduction facilities requirements and data reduction operations.

* To prepare and modify detailed flight experiment operating procedure sequences, including alternate emergency procedures, and criteria for operational decisions.

* To operate and maintain the Command and Data Handling Consoles in each DSIF station as required by each mission.

* To direct and coordinate all activities in support of each mission from the DOCF.

- Reporting Phase

Upon the completion of each flight experiment of Project Surveyor and the reduction of the data obtained, a major task of this activity will be the preparation and coordination of a spacecraft launch operations report, a Surveyor Transit and Lunar Operations report, and a Mission Engineering and Scientific Data Report.